REMARKS

In response to the Office Action mailed August 28, 2002, Applicant respectfully requests reconsideration. To further the prosecution of this application, Applicant has addressed herein each of the issues raised in the Office Action by amending the claims and submitting the following remarks.

Claims 1, 6, and 13-66 are pending in this application, of which claims 1, 6, 61, 62, 63, 65 and 66 are independent claims. In this amendment, claims 1 and 6 have been amended, claims 2-5 and 7-12 have been cancelled and claims 13-66 have been added to further define Applicant's contribution to the art. All of the new claims clearly are supported by the specification as originally filed, and no new matter is added. The application as now presented is believed to be in allowable condition.

A. <u>Summary Of The Present Invention As Claimed</u>

The present invention is directed generally to methods and apparatus for compensating a radiation sensor for changes in one or more operational characteristics of the sensor due to a temperature variation of the sensor. In one embodiment, as discussed in connection with Figs. 1-3 of Applicant's specification, the radiation sensor may be formed of a number of microbolometer elements, whose respective resistances change with variations in a temperature of the elements. The microbolometer elements are employed to generate output signals in response to thermal radiation emitted by an object of interest in a scene, which changes the temperature and hence resistance of the elements as it impinges on the sensor. Sensor output signals due to these resistance changes are processed to produce a video image of the object of interest.

Applicant's specification discusses examples of operational characteristics of the sensor, relating to non-uniformities amongst the microbolometer elements, that may change as a function of temperature and adversely affect image quality (specification, pages 16-18). One such operational characteristic that may change as a function of temperature is referred to as "offset error variation," and another such operational characteristic that may change as a function of temperature is referred to as "gain variation."

In particular, Applicant's specification explains that the nominal resistance of each bolometer of the radiation sensor at a given sensor temperature may be different under similar sensing circumstances. The variation in nominal resistance from bolometer to bolometer at a given sensor temperature, with reference to an average nominal resistance of all of the bolometers, is referred to as "offset error." This offset error of each bolometer in the radiation sensor may change as the overall temperature of the sensor varies. Additionally, the change in offset error due to a change in sensor temperature may be different from bolometer to bolometer. The change in the offset error of each bolometer due to temperature variations of the sensor is referred to as "offset error variation."

Applicant's specification also explains that the response to radiation of interest of one bolometer compared to another bolometer at a given sensor temperature may be different. The variation in response from bolometer to bolometer at a given sensor temperature is referred to as "gain error." Like the offset error discussed above, the gain or response of each bolometer in the radiation sensor may change as the temperature of the sensor varies. Additionally, the change in bolometer gain due to a change in sensor temperature may be different from bolometer to bolometer. This change in the gain value of each bolometer due to a change in sensor temperature is referred to as "gain variation."

Applicant's specification explains that, conventionally, offset error variation and gain variation are minimized by thermally stabilizing the radiation sensor at a fixed temperature (a "calibration" temperature). Once the radiation sensor is stabilized at a fixed calibration temperature, the offset error and gain non-uniformities amongst the sensors at the calibration temperature can be compensated for in sensor output signals to improve the image quality of an object of interest.

In particular, offset error values and gain values for respective bolometers of the radiation sensor may be collectively referred to as "calibration parameters," as these parameters typically are determined under particular calibration conditions prior to normal operation of the sensor (e.g., a particular calibration temperature and sensing condition) (see specification, page 15, lines 11-17; page 19, lines 17-19). Specifically, at a fixed calibration temperature, the offset error and gain of each bolometer of the sensor can be determined and stored in memory (e.g., as a table or map). These values then can be applied to output signals from each bolometer of the sensor to

compensate for non-uniformities amongst the bolometers as long as the sensor is thermally stabilized at the calibration temperature.

It should be appreciated, however, that *this process is only effective over a very small range of temperatures around the calibration temperature*; in particular, the offset error and gain values obtained at the calibration temperature generally are no longer accurate at other possible sensor temperatures, due to offset error variation and gain variation as discussed above (which can be significant even with small temperature deviations from the calibration temperature).

In view of the forgoing, one embodiment of the present invention is directed to methods and apparatus for dynamically adjusting one or both of the offset error and gain calibration parameters in response to temperature variations of the radiation sensor, so as to compensate for offset error variation and/or gain variation. By dynamically adjusting one or both of these calibration parameters in response to temperature variations of the radiation sensor, the sensor may be allowed to significantly vary in temperature during normal operation (either freely, or at various predetermined set-points), thereby reducing or eliminating the need for thermal stabilization of the sensor at a single calibration temperature. By reducing or eliminating the need for thermal stabilization of the sensor, the overall cost, complexity and power consumption of a system employing the radiation sensor may be reduced.

According to various aspects of the invention, one or both of the offset error and gain calibration parameters obtained at a particular initial calibration temperature may be dynamically adjusted on a bolometer by bolometer basis, based on temperature variations of the sensor significantly above or below the calibration temperature. Such an adjustment of the calibration parameters may be accomplished using linear approximations of offset error variation and gain variation over a particular anticipated temperature range, interpolations of piece-wise linear approximations of offset error variation and gain variation, or nonlinear offset error and gain variation functions. In other aspects, in addition to dynamic adjustment of calibration parameters, one or more operating parameters of the sensor (e.g., bias voltage and/or current) may be dynamically adjusted to compensate for temperature variations of the sensor. These concepts are discussed in greater detail in Applicant's specification, in connection with Figs. 6-11.

The above overview of the invention is provided merely to assist the Examiner in appreciating various aspects of the present invention. However, the Examiner is respectfully

requested to give careful consideration to the specific language of each of the independent and dependent claims, and to address each on its own merits.

B. Rejections Under 35 U.S.C. §102

Claims 1-12 were rejected under 35 U.S.C. §102(b) as allegedly being anticipated by Parrish et al (U.S. Patent No. 5,756,999). Since claims 2-5 and 7-12 have been cancelled, the rejection is now moot with respect to these claims. Although Applicant's do not concede that the rejections of claims 1 and 6 were proper, these claims have been amended herein in an effort to expedite prosecution. Applicant reserves the right to file one or more related applications directed to the subject matter of the claims prior to the amendments herein.

Claim 1, as amended, is directed to a method of compensating a radiation sensor for changes in at least one operational characteristic of the sensor due to a temperature variation of the sensor. The method comprises an act of dynamically adjusting at least one calibration parameter associated with the radiation sensor based on the temperature variation of the sensor.

Similarly, claim 6 is directed to an apparatus comprising a controller to compensate a radiation sensor for changes in at least one operational characteristic of the sensor due to a temperature variation of the sensor. The controller is configured to dynamically adjust at least one calibration parameter associated with the radiation sensor based on the temperature variation of the sensor.

As discussed in further detail below, Parrish does not disclose or suggest the concept of dynamically adjusting one or more calibration parameters (e.g., offset error and gain) based on a temperature variation of a radiation sensor, as recited in independent claims 1 and 6. Therefore, it is respectfully believed that each of these claims patentably distinguishes over Parrish and is in condition for allowance.

1. Discussion of Parrish

In contrast to Applicant's independent claims 1 and 6, the disclosure of Parrish is limited to calibration parameters (e.g., offset error and gain coefficients) which are determined once at a single temperature at which a sensor is stabilized. These calibration parameters are not varied or otherwise adjusted thereafter.

Specifically, Parrish discusses only a conventional "two-point correction" technique in connection with Figs. 15-20 of Parrish. In particular, beginning on line 21 of column 2, Parrish describes a standard two-point correction technique in which gain non-uniformity correction is implemented by multiplying the output signal of each bolometer in a sensor array by a unique gain coefficient. Similarly, offset error non-uniformity correction is implemented by adding a unique offset coefficient to the output signal of each bolometer (Fig. 15; col. 2, lines 25-32; col. 6, lines 28-43).

Parrish goes on to describe that values for the gain and offset correction coefficients are generated and stored during a calibration process *in which the sensor substrate is held at a constant temperature* (col. 6, lines 61-64; emphasis added). Once these coefficients are obtained at a particular substrate temperature T_1 and stored in memory, they are retrieved and applied to the respective bolometer output signals in the multiply and division processes indicated in Fig. 15 (col. 6, line 65 – col. 7, line 14).

Parrish corroborates that one problem with the standard two-point gain and offset correction method is that it is only effective at compensating bolometer non-uniformities over a very small range of sensor substrate temperatures, on the order of 0.005-0.025 degrees Kelvin (col. 2, lines 43-47; col. 6, lines 57-60). In order to maintain the substrate or sensor temperature within these very tight temperature tolerances, Parrish points out that conventional microbolometer detector systems typically require a thermo-electric cooler, temperature sensor, vacuum packaging systems, temperature control electronics, and complex processing electronics, which added to system cost and complexity (col. 2, lines 47-50; col. 8, lines 3-7).

In view of the foregoing, Parrish is directed primarily to compensation techniques that permit a somewhat less stringent thermal stabilization range for a radiation sensor (e.g., over a range of 10 degrees Kelvin), while still providing sufficient non-uniformity correction using a conventional two-point gain and offset correction technique (col. 9, lines 11-15; col. 8, lines 24-29). In particular, in one embodiment of Parrish, a non-uniform bias is applied to a microbolometer array such that a ratio of the output signals from individual bolometers remains nearly constant as the sensor substrate temperature changes slightly from the stabilization or calibration temperature (col. 8, lines 56-61). It is noteworthy however, that in Parrish, after the non-uniform bias is applied to the microbolometer array, a standard two-point gain and offset

correction technique is used to address the non-uniformities in the properties of the microbolometer detectors (col. 8, lines 61-65).

In sum, it should be readily appreciated from the disclosure of Parrish that gain and offset correction coefficients are initially determined at single calibration temperature, stored in memory, and subsequently applied to microbolometer output signals, as illustrated in Fig. 15 of Parrish. *However, nowhere in the reference does Parrish disclose or suggest that any of the gain and offset correction coefficients are varied or dynamically adjusted at any time in response to changes in substrate or sensor temperature.* Instead, Parrish merely discloses that a non-uniform bias is applied to the microbolometer array to provide substrate temperature compensation, followed by conventional two-point gain and offset correction using fixed offset and gain coefficients determined at a single calibration temperature.

2. <u>Claims 1 and 6 Patentably Distinguish over Parrish</u>

In contrast to Parrish, Applicant's independent claims 1 and 6 recite that at least one calibration parameter associated with a radiation sensor is dynamically adjusted based on a temperature variation of the sensor. As discussed above in Section A, examples of calibration parameters include an offset error value for each radiation detector of the sensor and a gain value for each radiation detector of the sensor. Parrish is completely silent with respect to varying or adjusting calibration parameters such as offset error and gain. Accordingly, Applicant's independent claims 1 and 6 patentably distinguish over Parrish and are in condition for allowance. Therefore, it is respectfully requested that the rejections of claims 1 and 6 under 35 U.S.C. §102(b) as allegedly being anticipated by Parrish be withdrawn.

C. <u>Applicant's New Claims Also Recite Several Patentable Features</u>

Newly presented claims 13-66, which are fully supported in Applicant's specification as filed, have been added to more fully define Applicant's contribution to the art. New dependent claims 13-60 depend from one of claims 1 and 6, and are believed to be patentable based at least on their dependency. This notwithstanding, the new claims recite several additional features that are believed to patentably distinguish over Parrish.

For example, nowhere in the reference does Parrish disclose or suggest applying a compensation function to one or more calibration parameters, wherein the compensation function

may include a linear approximation, an interpolation of a piece-wise linear approximation, or a nonlinear function of changes in operational characteristics of the sensor due to temperature (e.g., see claims 16-18 and 40-42).

Additionally, nowhere in the reference does Parrish disclose or suggest allowing a temperature of a radiation sensor to freely vary (e.g., applying essentially no thermal stabilization to the radiation sensor), or thermally stabilizing a radiation sensor at a plurality of different temperatures based on an ambient temperature in proximity of the sensor (e.g., as recited in Applicant's claims 19-23, 43-47, and 61-63). Instead, Parrish discloses only that a substrate temperature of a microbolometer focal plane array is stabilized at a particular fixed temperature by heating rather than cooling the substrate (Parrish, col. 24, lines 30-65).

Furthermore, nowhere in the reference does Parrish disclose or suggest selecting predetermined stabilization temperatures for a radiation sensor so as to approximately minimize a power consumption of a thermal stabilization device (e.g., as recited in Applicant's claims 26, 50 and 64), dynamically adjusting a DC bias voltage and a DC bias current applied to the sensor so as to maintain an essentially constant bias power (e.g., as recited in Applicant's claims 35, 59 and 65), and dynamically adjusting an amplitude of an AC bias waveform applied to the sensor based on a temperature variation of the sensor (e.g., as recited in Applicant's claims 36, 60 and 66).

The foregoing illustrates merely some examples of various features recited in the new claims that are believed to be patentable over Parrish.

D. Conclusion

In view of the foregoing amendments and remarks, this application should now be in condition for allowance. A notice to this effect is respectfully requested. If the Examiner believes, after this amendment, that the application is not in condition for allowance, the Examiner is requested to call the Applicants' attorney at the telephone number listed below to discuss any outstanding issues relating to the allowability of the application.

If this response is not considered timely filed and if a request for an extension of time is otherwise absent, Applicants hereby request any necessary extension of time. If there is a fee occasioned by this response, including an extension fee, that is not covered by an enclosed check, please charge any deficiency to Deposit Account No. 23/2825.

Respectfully submitted,

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VERSIONS WITH MARKINGS TO SHOW CHANGES MADE

Claims 1 and 6 have been amended as follows:

1. (Amended) A method of compensating a radiation sensor for changes in at least one operational characteristic of the sensor due to a temperature variation of the sensor, comprising an act of:

<u>a)</u> dynamically adjusting [at least one of at least one operating parameter associated with the radiation sensor and] at least one calibration parameter associated with the radiation sensor based on the temperature variation of the sensor.

6. (Amended) An apparatus, comprising:

a controller to compensate a radiation sensor for changes in at least one operational characteristic of the sensor due to a temperature variation of the sensor, the controller <u>configured to</u> dynamically [adjusting at least one of at least one operating parameter associated with the radiation sensor and] <u>adjust</u> at least one calibration parameter associated with the radiation sensor based on the temperature variation of the sensor.